GROWTH AND FOOD CONSUMPTION IN YOUNG AMBERFISH, SERIOLA QUINQUERADIATA (T. et S.)

GROWTH AND FOOD CONSUMPTION IN YOUNG AMBER-FISH, *SERIOLA QUINQUERADIATA* (*T. et S.*)

By

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The amber-fish ("Buri" in Japanese), *Seriola quinqueradiata* (TEMMINCK et SCHLEGEL), is one of the most important commercial species on each side of Japan from Hokkaido to Formosa. It stands at a high trophic level among the warm water fishes living together with anchovy, sardine, mackerel, saurel and squid. It usually migrates in schools, selecting coastal waters having a temperature of 10° to 20°C. According to the Japan Fisheries statistics (4), the catch in recent years are rather stable, being: 58.7 in 1952, 48.7 in '53, 46.4 in '54, 46.2 in '55 and 42.9 in '56 in thousand tons. It is usually caught by deep-sea trap-nets, rolling gill-nets, setline and hooks.

Since 1956, investigations on the collected samples and feeding experiments of this fish were undertaken, and some results were obtained concerning the amounts of food consumption for the growth of the individual fish in nature.

Materials used for the investigations on seasonal growth and stomach contents in nature consisted of 62 samples, including 1,371 specimens, collected mainly from the coastal waters of Miyagi Prefecture. They were caught by trap-net or setline and hooks during 1956 and 1957. The feeding experiments of the young amber-fish were undertaken using a few concrete aquaria, measuring 4×3 m in size and 1 m in depth, at the Onagawa Fisheries Laboratory, Tohoku University. Care was taken to make the conditions as close as possible to the natural environment of the fish.

Before the feeding experiments, the amber-fish were accustomed to artificial feeding in the aquaria for about a week. The number of fish admitted at a time in the aquaria was three to six individuals, which were distinguished from one another by size and other characteristics. The fish, ranging from 28 g to 1530 g in body weight, were fed with the anchovy (*Engraulis japonicus*) or the squid (*Ommastrephes sloani pacificus*), at various temperatures from 10.8° to 24.1°C.

The fish were fed twice a day at morning and evening, and the amount of food taken by each individual was recorded. The fish were weighed and measured once per ten days after slightly narcotized by 1 per cent urethan solution, whose effects lasted only for a quarter of an hour and there-after the fish fed as before.

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Seasonal Growth of Young Amber-Fish

The range and the mode of the length frequency of each sample are plotted in Fig. 1 according to the time of collection. In this figure, the actual

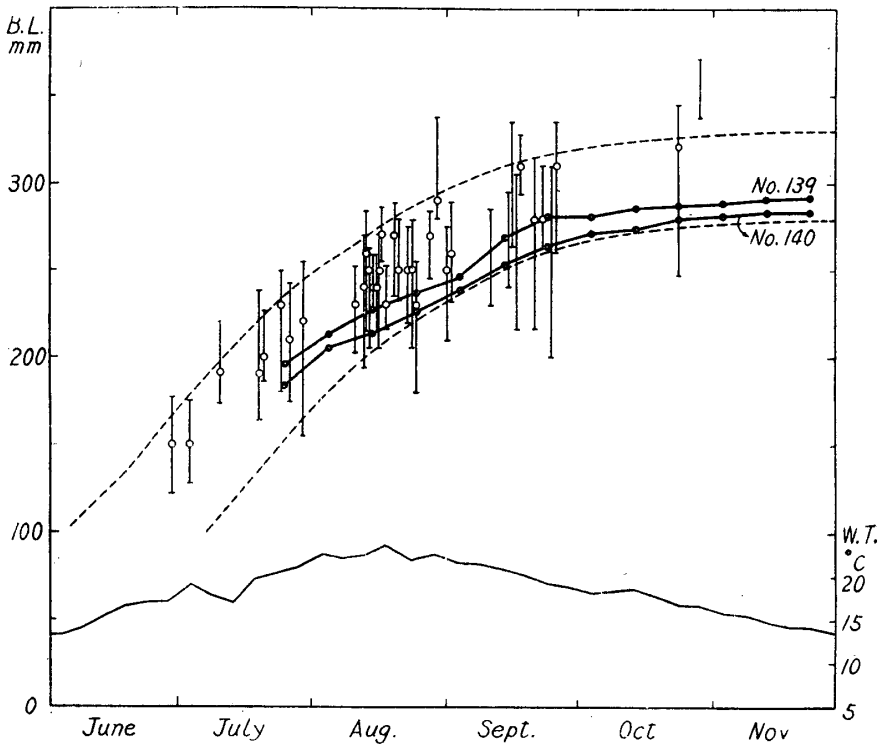

Fig. 1. The range and the mode of the length frequency of each sample of the amber-fish collected in Miyagi Prefecture. The growth curves of the reared fish are inserted by solid circles. The water temperature variation in Onagawa Bay in 1957 are shown at the lowest step.

growth curves of the reared fish (Nos. 139 and 140) are inserted after the date of the feeding experiment. The spawning of the amber-fish is believed to occur mainly between March and May on the Pacific side (6). Making a general consideration on the seasonal variation of the modal length of the

collected samples and the growth curve of the reared fish, together with the hatching period, the seasonal growth curve of the 0-year old amber-fish were depicted appropriately by free hand as a curved band in this figure by a dotted line.

The length at the end of the year can be estimated to be nearly 30~33 cm, which is generally coincident with the results of the previous investigators (1, 3, 5). The fish of about 15 cm long and 60 g in weight at the end of June grows to 30 cm long and 460 g at the end of September, thus the growth in summer attains approximately half of that attained in a year. The growth rate of the reared fish seem to decrease towards and until after October compared with those in nature, where the water temperature becomes a little higher than that in the aquaria. In general, the growth of the reared fish is practically the same as that in nature, thus the fish is considered to be kept in proper condition within the artificial environment of the aquaria.

Stomach Contents

The stomach contents of the amber-fish in nature were investigated on the samples collected from Onagawa Bay and Sendai Bay during June to October of 1956 and 1957. They consisted of 23 samples, including 538 individuals, ranging from 122 mm to 325 mm, of the 0-year old fish, and six samples, including 78 individuals, ranging from 313 mm to 372 mm, of the one-year old fish.

The date and the locality of collection, the number of fish investigated, the range and the mode of the length frequency of each sample, the rate in number of empty stomachs and the rate in number of stomachs containing each listed food item are shown in Table 1. There can be found no noteworthy differences in general features of the contents between both years. The rates of the empty stomachs varied from 0 to 80 per cent and 31 per cent in an average. Such a high rate is probably due to the time of collection being at dawn and to the non-feeding habit at midnight.

The food of the fish exceeding at least 12 cm in length are composed only of the various fishes, without phytoplankton, pelagic crustaceans or benthic animals. As can be seen from the rate in number of stomachs containing each listed food items, the anchovy (*Engraulis japonicus*) occupied 46 percent, the saurel (*Trachurus japonicus*) 21 per cent, the squid (*Ommastrephes sloani pacificus*) 13 per cent and the other fishes five per cent in an average for the collected samples. The growth of the amber-fish in warm seasons seems to depend mainly on the anchovy.

Among the sample including 27 individuals, ranging from 120 g to 196 g in weight, collected on July 20 in Onagawa Bay, 22 stomachs contained only the anchovy, whose weights varied between 1.5 g and 20.8 g, and the feeding

Table 1. Stomach contents of the amber-fish collected in Miyagi Prefecture in 1956 and 1957.

Date	Locality	No. of fish	Mode of b.l. mm	Range of b.l. mm	Empty stomach %	Percent. of stomach containing each food item				
						Anchovy	saurel	squid	fishes	digest. frag.
June 29, '57	Onagawa Bay	63	150	122～176	79.4	—	—	11.1	1.6	7.9
July 3, ,,	,,	36	150	128～174	83.3	—	—	5.6	—	11.1
,, 10, ,,	,,	32	190	173～219	34.4	15.6	3.1	6.3	3.1	37.5
,, 19, ,,	Sendai Bay	32	190	163～238	59.4	12.5	6.3	—	—	21.9
,, 20, ,,	Onagawa Bay	27	200	186～227	7.4	81.5	—	—	—	11.1
,, 29, ,,	Sendai Bay	31	220	154～255	35.5	—	22.6	—	3.2	38.7
Aug. 12, ,,	,,	32	240	193～269	46.9	46.9	—	—	—	6.2
,, 15, ,,	,,	33	240	217～258	9.1	30.3	15.2	12.1	—	33.3
,, ,, '56	Onagawa Bay	20	240	226～259	20.0	15.0	20.0	—	45.0	—
,, 21, '57	Sendai Bay	30	270	237～289	40.0	13.3	13.3	—	3.3	30.0
,, 23, ,,	,,	32	250	206～279	65.6	—	31.3	—	—	3.1
,, 24, ,,	,,	40	230	180～255	65.0	—	25.0	2.5	—	7.5
,, 27, ,,	,,	20	270	246～283	60.0	15.0	10.0	10.0	—	5.0
,, 29, ,,	,,	20	—	281～338	15.0	80.0	—	5.0	—	—
,, 31, ,,	,,	26	250	210～275	23.1	34.6	—	7.7	—	34.6
Sept. 1, ,,	,,	21	240	212～296	9.5	66.6	9.5	9.5	—	4.8
,, 10, ,,	,,	21	280	230～286	19.0	9.5	61.9	4.8	4.8	—
,, 16, ,,	,,	23	280	217～305	8.7	52.2	21.8	17.4	—	—
,, 17, '56	Onagawa Bay	10	310	294～328	20.0	10.0	40.0	—	30.0	—
,, 18, '57	Sendai Bay	20	280	215～314	5.0	35.0	15.0	40.0	—	5.0
,, 20, ,,	,,	20	280	233～295	50.0	—	5.0	35.0	5.0	5.0
,, 22, ,,	,,	20	280	265～310	0	20.0	20.0	55.0	5.0	—
,, 25, ,,	,,	19	310	261～335	0	47.3	21.0	26.3	5.3	—
				Average	32.9	25.4	14.8	10.8	4.6	11.4
July 7, '57	Sendai Bay	17	325	313～367	29.4	52.9	—	—	—	17.6
,, 11, ,,	,,	22	360	329～395	27.3	72.8	—	—	—	—
,, 13, ,,	,,	11	370	324～400	18.2	36.4	18.2	—	—	27.3
,, 18, ,,	,,	10	370	353～408	40.0	50.0	10.0	—	—	—
,, 28, ,,	,,	10	370	363～401	20.0	60.0	20.0	—	—	—
Oct. 28, '56	Onagawa Bay	8	350	338～372	12.5	62.5	25.0	—	—	—
				Average	24.6	55.8	12.2	0	0	7.5
					31.2	31.7	14.3	8.6	3.7	10.6

rate was 4.7 per cent in an average, showing 11.2 per cent at the maximum. Another example of fully filled stomach was found among the specimens collected on October 28, off Enoshima-Island, Miyagi Prefecture. Among them, a fish, 367 mm long, contained 32 anchovies, weighing 102.5 g, corresponding to 10.4 per cent of the body weight.

It is easily deemed from the above observations on the stomach contents that the amber-fish consume quite a large amount of anchory yearly in nature.

Feeding Experiment

The mean weight between the initial and the final weights of the fish during the experimental period, usually divided at every 10 days, was called the average body weight, and the rate in weight of daily food consumption or of daily growth (on an average for each 10 days period) against the average

body weight was indicated respectively as the daily rate of feeding or the daily rate of growth. The rate in weight of the growth against the food consumption is named as the efficiency of conversion.

The chemical analysis of the general composition of the amber-fish used in this experiment showed as water content 68.3 per cent, crude protein 21.4, crude fat 9.7 and ash 2.6 percent, hence one gram of the fish is equivalent to 1.78 kcal. The values of 0.67 kcal and 0.82 kcal per gram were used respectively for the anchovy and the squid used for food at the calculation on energy basis.

(1) Effect of the fish size.

Considering from the results of investigation on the stomach contents, it seems not to happen that the anchovy is unsuitable for food for fish within the size range of this experiment. The variation of the rate of feeding and of growth was investigated among the various sized fish given the anchovy for food. Fifty-four cases were obtained from the feeding experiments, each

Table 2. Feeding rates, growth rates and efficiencies of conversion of the amber-fish fed with anchovy at the temperature range between 19.7° and 22.4°C, arranged according to the body weight.

Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %	Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %
105	10	49.6	12.66	3.39	26.75	139	20	204.5	9.05	1.64	18.10
106	,,	57.1	15.09	5.24	34.73	140	,,	205.5	9.51	1.78	18.67
104	,,	63.7	9.72	2.90	29.88	132	10	208.5	7.28	1.10	15.14
105	,,	70.0	11.57	3.43	29.63	133	30	214.5	6.52	0.85	13.10
103	,,	89.8	12.55	3.83	30.52	134	,,	215.0	6.71	1.15	17.09
104	,,	90.5	10.93	3.87	35.39	136	20	216.0	6.32	0.69	10.99
106	,,	92.0	13.63	4.35	31.90	137	10	223.0	8.22	1.34	16.36
101	,,	99.0	9.79	3.03	30.96	142	,,	224.0	6.49	0.89	13.75
140	,,	101.0	13.97	3.96	28.35	138	,,	225.0	6.40	1.33	20.82
107	20	104.8	8.24	2.27	27.49	131	20	227.0	9.11	1.54	16.92
138	10	117.0	9.89	2.22	22.47	132	,,	249.5	4.92	0.42	8.55
139	,,	122.5	11.88	3.51	29.55	137	10	249.5	5.78	0.92	15.94
103	,,	124.5	9.74	2.81	28.85						
101	,,	131.5	9.17	2.66	29.02	140	10	260.0	7.30	1.38	18.97
140	,,	136.0	9.90	2.20	22.29	133	20	262.5	7.00	0.70	10.07
138	,,	139.5	6.24	1.36	21.81	134	10	264.0	6.23	0.91	14.58
						132	,,	271.0	6.46	0.81	12.56
136	20	153.5	6.08	0.88	14.46	139	20	283.0	8.31	1.59	19.14
137	,,	155.0	7.88	1.03	13.09	133	10	289.5	6.26	0.59	9.38
135	10	157.5	5.35	0.95	17.79	132	,,	291.0	4.57	0.62	13.52
139	,,	157.5	9.78	1.71	17.53	146	,,	303.0	7.13	0.99	13.88
140	,,	160.0	8.69	1.12	12.94	131	20	303.0	8.28	1.35	16.34
138	20	163.5	6.97	0.89	12.72	144	10	308.0	5.76	0.52	9.01
134	,,	166.0	7.01	0.72	10.31	147	,,	316.0	8.99	0.89	9.85
137	10	178.0	6.74	0.79	11.67	144	,,	323.5	4.84	0.46	9.57
136	20	184.0	6.73	0.92	13.73	146	,,	326.0	5.70	0.49	8.61
138	10	194.0	8.89	1.65	18.56	147	,,	343.0	6.56	0.76	11.55
137	,,	196.5	7.47	1.17	15.67						
142	20	198.5	6.16	0.78	12.68						

lasted for 10~30 days, using the fish between 49.6 g and 397.0 g in weight under the water temperature from 19.7° to 22.4°C. The rates of feeding and of growth are shown in Table 2, according to the size of the fish. When they are divided into three size groups, the range and the mean of the feeding rate and of the growth rate within the respective group are calculated as follows:

	Range of body weight g	No.	Mean body weight g	Range of daily rate of feeding & (mean) %	Range of daily rate of growth & (mean) %	Efficiency of conversion %
[1]	49.6-139.5	16	99.28	6.24-15.09(10.94)	1.36-5.24(3.19)	29.07
[2]	153.5-249.5	24	196.92	4.92- 9.78(7.25)	0.42-1.78(1.09)	13.65
[3]	260.0-343.0	14	295.96	4.57- 8.99(6.67)	0.46-1.59(0.86)	12.91

The daily rate of feeding is rather variable among individuals probably due to the physiological conditions of the fish. However, it is obvious that this rate decreases as the fish grow larger and consequently the rate of growth also decreases according to size, as shown in Fig. 2. The relation between growth and food consumption should be obtained for each size range.

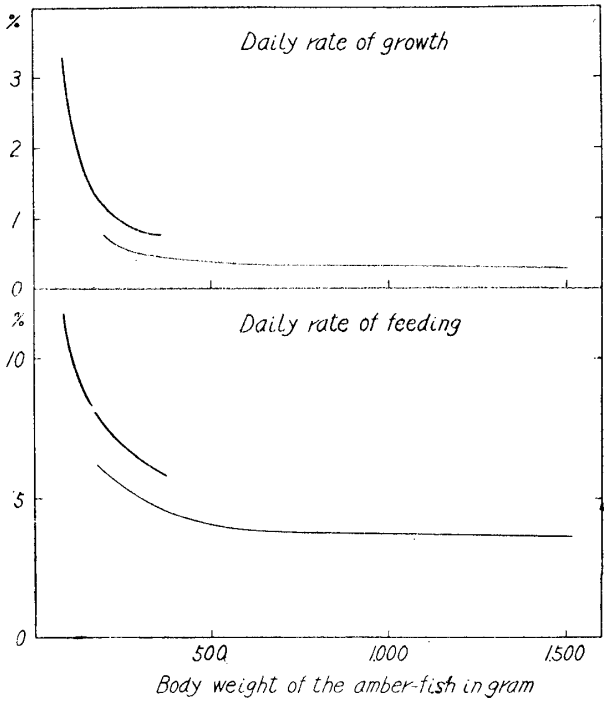

Fig. 2. Daily rate of growth and daily rate of feeding of the amber-fish fed with anchovy, showing their variations according to the body weight, separately for the water temperatures. The light lines for 15.2° and the heavy lines for 21.2°C.

(2) Effect of the temperatures

Feeding experiments were also undertaken under a lower range of tem-

Table 3. Feeding rates, growth rates and efficiencies of conversion of the amber-fish fed with anchovy at the temperature range between 11.6° and 18.6°C, arranged according to the body weight.

Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %	Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %
18	10	202.0	7.77	1.39	17.83	133	10	331.0	5.35	0.54	10.16
19	20	206.0	4.97	0.58	11.74	144	,,	335.5	3.47	0.27	7.74
17	10	209.0	9.62	1.63	16.92	139	30	339.0	4.48	0.22	4.83
154	,,	209.0	4.76	0.48	10.05	132	10	344.5	4.37	0.26	5.98
16	,,	212.0	10.09	1.13	11.21	144	,,	348.0	5.84	0.46	7.87
20	,,	213.5	5.15	0.80	15.45	133	,,	348.0	5.52	0.46	8.33
18	,,	227.0	5.33	0.97	18.18	146	20	350.0	4.64	0.46	9.86
20	20	233.0	4.51	0.47	10.46	139	10	353.5	5.02	0.20	3.94
142	10	242.0	4.70	0.49	10.54	132	,,	356.5	4.70	0.42	8.96
16	30	243.0	4.98	0.52	10.46	133	,,	364.0	5.01	0.44	8.78
17	20	244.0	5.18	0.74	14.28	139	,,	364.5	4.33	0.41	9.50
18	10	244.5	3.34	0.53	15.93	133	10	375.0	2.94	0.27	9.08
136	20	244.5	5.47	0.52	13.83	144	20	382.0	6.42	0.68	10.59
142	10	253.0	6.15	0.39	6.43	147	30	383.0	5.53	0.47	8.49
18	,,	258.5	5.25	0.56	11.05	146	20	385.0	6.16	0.49	8.02
15	,,	261.0	5.82	0.61	10.53						
137	,,	265.0	4.11	0.34	8.26	131	10	401.5	5.54	0.30	9.43
142	30	269.0	3.48	0.27	7.75	145	,,	414.0	4.23	0.29	6.86
15	10	274.5	3.83	0.40	10.48	144	,,	415.0	4.60	0.34	7.33
136	,,	278.0	5.79	0.72	12.43	147	,,	417.0	5.77	0.34	5.82
137	30	280.0	4.63	0.24	5.14	146	20	417.0	3.88	0.31	8.02
140	10	283.0	5.08	0.35	6.95	145	10	427.0	4.24	0.33	7.73
134	30	287.0	4.11	0.25	6.21	147	20	435.0	3.32	0.25	7.61
15	10	290.0	3.46	0.51	14.84	131	,,	439.0	4.82	0.62	12.76
136	,,	294.0	4.55	0.41	8.97	26	30	440.0	3.04	0.27	8.96
140	,,	295.0	5.78	0.47	8.21	145	10	455.0	6.47	0.92	14.27
133	,,	303.0	5.81	0.33	5.68	131	10	465.5	3.65	0.24	6.48
136	,,	304.0	4.09	0.26	6.44	131	,,	481.0	4.48	0.42	9.28
15	,,	305.5	3.90	0.36	9.24	145	,,	485.0	4.38	0.37	8.48
134	,,	308.0	5.71	0.65	11.37	131	,,	493.5	2.27	0.10	4.47
140	,,	311.0	4.47	0.58	12.95	145	,,	498.0	3.97	0.16	4.05
136	,,	311.0	2.18	0.19	8.86	145	,,	505.0	3.68	0.12	3.23
133	,,	315.0	4.84	0.44	9.17	32	30	593.0	3.55	0.37	10.42
132	30	320.0	4.13	0.42	10.08	31	,,	651.5	2.91	0.43	14.58
134	10	323.0	5.43	0.31	5.70	30	,,	688.5	3.65	0.27	7.29
140	,,	327.5	5.13	0.46	8.93	29	,,	740.0	3.21	0.23	7.08

perature than that of the previous experiments. Under the temperature condition between 11.6° and 18.6°C (15.2°C in an average), the fish, weighing between 202.0 g and 704.0 g, was likewise reared giving the anchovy for food. The results are shown in Table 3. When they are divided into two groups by size, the rate of feeding and of growth are as follows:

	Range of body weight g	No.	Mean body weight g	Range of daily rate of feeding & (mean) %	Range of daily rate of growth & (mean) %	Efficiency of conversion %
〔4〕	202.0-385.0	51	294.22	2.18-10.09(5.03)	0.19-1.63(0.51)	10.1
〔5〕	401.5-704.0	20	491.3	2.27- 6.47(4.08)	0.10-0.92(0.33)	8.0

Making a comparison between the results [4] and [3], the rate of feeding and of growth obviously decreases as the temperature becomes lower.

The fish of one-year in age, weighing 1,490 g, was reared for 30 days under the temperature of 15.2°C, giving the anchovy for food. This is only one case for the one-year old fish, and the feeding rate was 3.79 per cent, the growth rate 0.18 per cent and the efficiency of conversion 4.75 per cent. Under the lower temperature also, the rate of feeding and of growth decreases as the fish grow larger (Fig. 2).

(3) Effect of the kind of food.

The food of the amber-fish consisted, other than the anchovy, of the saurel and the squid. With regard to this, the feeding experiments were likewise undertaken giving the squid (*Ommastrephes sloani pacificus*) for food. The amber-fish, weighing between 42.8 g and 146.8 g, were sufficiently fed with a part of the mantle of the refrigerated squid, under the temperature between 19.7° and 22.8°C.

Table 4. Feeding rates, growth rates and efficiencies of conversion of the amber-fish fed with squid at the temperature range between 19.7° and 22.8°C.

Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %
5	10	42.8	17.31	7.41	42.73
4	,,	51.0	13.20	5.67	42.90
5	,,	74.5	12.08	4.70	38.89
4	,,	79.8	12.78	3.95	30.88
3	,,	91.3	12.46	3.59	28.81
2	,,	99.5	16.35	4.35	26.64
3	,,	125.5	9.56	3.11	32.50
1	,,	140.3	9.55	2.67	28.19
2	,,	146.8	11.04	3.78	34.26
Average		94.61	12.70	4.36	33.98

As shown in Table 4, the daily rate of feeding was 12.70 per cent and the daily rate of growth 4.36 per cent in an average for the fish of nearly 100 g. When these are compared with the results fed with anchovy (c. f. [1]), the squid was found to be a superior food for the amber-fish. However, on an energy basis, the efficiency of conversion of the squid is 74.5 per cent, being nearly equal to that of the anchovy (77.2 per cent).

(4) Effect of the excess amount of food

When the amber-fish are reared with the same sized mackerel (*Pneumatophorus japonicus*) in the same pool, the amounts of food eaten increase compared with the case in which they are reared separately. By means of this method, seven fish, weighing between 123.8 g and 199.3 g, were fed sufficiently

as possible with the anchovy under the temperature of 21.0°C.

As shown in Table 5, the amber-fish weighing nearly 150 g, showed the rate of feeding at 16.8 per cent, the rate of growth to be 4.1 per cent and the

Table 5. Feeding rates, growth rates and efficiencies of conversion of the amber-fish, when reared together with the mackerel and fed with the anchovy at the temperature range between 19.2° and 23.6°C.

Fish No.	Exp. period days	Ave. b. w. g	Daily rate of feeding %	Daily rate of growth %	Efficiency of conv. %
13	10	123.8	19.71	6.25	25.61
14	,,	125.0	16.96	4.48	26.42
12	,,	134.8	16.99	4.49	26.42
11	,,	142.5	15.02	3.86	25.70
10	,,	145.5	15.95	3.64	22.84
9	,,	177.3	17.37	3.92	22.56
8	,,	199.3	15.70	3.39	21.57
Ave.		149.7	16.81	4.12	24.45

efficiency of conversion to be 24.5 per cent in an average. In comparison between this result and the moderate consumption of food showing a normal growth (c. f. [1] and [2]), the feeding rate indicates approximately twice the amount, but the efficiency of conversion remained unchanged. Hence, 17~20 per cent, of the feeding rate will be assumed as an upper limit suitable to the efficient growth proportional to the food consumption under the above mentioned circumstances.

Food Consumption by the Young Amber-fish

The relation between the food consumption and the growth under the feeding experiments was applied to the known rate of growth in nature to determine the yearly food consumption by the individual amber-fish. The regression line between the rate of feeding and of growth should be employed in correspondence to the size of the fish, to the seasonal variation of the inhabiting water temperature and to the kind of foods, since these are believed to be the most effective factors for the food consumption.

In summer, the young amber-fish is frequently caught at the water temperature of nearly 21°C in the North-East Sea Region of the Pacific coast of Japan, while in winter it inhabits in the waters between 14° and 17°C like the adult fish. The result of the feeding experiment in which the anchovy was used for food will be applicable for the other kinds of fish on an energy basis as previously mentioned.

From the results shown in Tables 2, 3 and 4, the regression lines between the daily rate of feeding (x) and the daily rate of growth (y) were calculated separately for the fish size under the different temperature conditions as

follows:

Mean water temperature °C	Range of body weight g	Mean body weight g	Numb. of fish	Kind of food	Regression line between the daily rate of feeding (x) and the daily rate of growth (y)
21.1	49.6-139.5	99.28	16	anchovy	$y=0.3942x-1.122$.....〔1〕
,,	153.5-249.5	196.92	24	,,	$y=0.2317x-0.587$.....〔2〕
,,	260.0-343.0	295.96	14	,,	$y=0.2068x-0.519$.....〔3〕
15.2	202.0-385.0	294.22	51	,,	$y=0.1547x-0.271$.....〔4〕
,,	401.5-704.0	491.28	20	,,	$y=0.1165x-0.142$.....〔5〕
21.3	42.8-146.8	94.61	9	squid	$y=0.4295x-1.098$.....〔6〕

Making a calculation of the seasonal growth of the fish shown in Fig. 1, the 0-year old fish was assumed to grow up, after being generated at the beginning of April, to 15 cm long, 60 g in weight at the end of June, to 23 cm, 190 g at the end of July, to 30.5 cm, 470 g at the end of September and to 35 cm, 800 g at the end of the following March.

The food consumption during 91 days from the hatching to growth up to 60 g can not precisely be estimated from the regression line, because the data are limited. However, presuming the efficiency of conversion during these early life at 30 per cent in an average, the amount of food consumption may be estimated at 200 g (130 kcal) of the anchovy. (The food of the larval stages of the amber-fish consisted, of course, mainly of small copepode-like crustaceans, but their weight may be a very small one.)

The daily rate of growth during 31 days of July can be calculated at 3.35 per cent from the growth made (130 g) against the average body weight (125 g). Applying the equation 〔1〕 to this growth rate, the daily rate of feeding becomes 11.34 per cent, hence the fish will consume 440 g or 300 kcal corresponding to the anchovy for the growth in July.

In this way, the amount of food necessary for the growth of the amber-fish was calculated, applying the equation 〔3〕 for the period of August and September and the equation 〔5〕 during the period between October and the following March respectively. The result is shown in the following Table.

Period	Days	Growth made (g)	Average body weight (g)	Daily rate of growth (%)	Daily rate of feeding (%)	Amount of food in g (kcal)
From Apr. to June	91	60	30	2.20	—	200(130)
July	31	130	125	3.35	11.34	440(300)
Aug. & Sept.	61	280	330	1.39	9.24	1860(1250)
From Oct. to Mar.	182	330	635	0.29	3.67	4240(2840)
Total	365	—	—	—	—	6740(4520)

In this manner, the 0-year old fish is estimated to consume for the growth during a year nearly 4520 kcal corresponding to 6.7 kg of the anchovy. Namely, the fish of 800 g in weight must have consumed nearly 8.4 times in weight of

the small-sized fish, such as the anchovy, the saurel and the squid. The feeding experiments on the larger sized amber-fish are planned to be undertaken.

Summary

(1) The growth of the young amber-fish was presumed from the seasonal variation of the body length of the collected samples, combined with the growth curve obtained from the feeding experiment. The 0-year old fish grows very rapidly in summer attaining more than half the weight at the end of the one year, when it becomes 35 cm long, weighing 800 g.

(2) The food of the amber-fish exceeding 12 cm in length consisted mainly of the anchovy, followed by the saurel and the squid. The standing amount of the stomach content in the state fully filled with the anchovy showed 11.2 percent of the body weight.

(3) The feeding experiments were undertaken on 126 cases, using the amber-fish between 28 g and 1530 g in weight, separately for the temperature conditions and for the kinds of food. And the results summarized in the six equations indicate the relation between the rate of feeding and of growth.

(4) The feeding rates of the fish in nature were calculated, utilizing the above equations, from the known rate of growth, and the food consumption of the 0-year old fish within a year was estimated in an average to be nearly 4520 kcal corresponding to 6.7 kg of the anchovy.

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